



and Fiji. A partially dried shell, without doubt belonging to the above species, was found in the dredgings north of Pava, Funafuti, 35 fathoms (David coll.).

## SECTION III. PLATYCOPA.

## Family CYTHERELLIDÆ.

CYTHERELLA, *Jones*.CYTHERELLA VENUSTA, *G. S. Brady*.

*Cytherella venusta*, G. S. Brady, 1880, Rep. Chall. Exped., Zool. pt. iii. p. 176, pl. xliii. figs. 4 *a-d*.

This elegant little form is quite common at Avalau Islet, Funafuti; and was found also in the sand from the 1st boring, near the surface (Sollas). The specimens on which Dr. Brady's description was based came from the reefs at Honolulu.

CYTHERELLA CINGULATA, *G. S. Brady*.

*Cytherella cingulata*, G. S. Brady, Les Fonds de la Mer, tom. i. p. 159, pl. xvii. figs. 24, 25; id., Rep. Chall. Exped., Zool. pt. iii. p. 177, pl. xliii. figs. 1 *a-g* and figs. 2 *a-d*.

This species has been previously found in shallow water at Hong Kong, Port Jackson, and off Booby Island.

*C. cingulata* is very rare at Avalau Islet, Funafuti (Sollas coll.).

## EXPLANATION OF PLATE 37.

- Fig. 1. *Argillæcia affinis*, sp. nov.: *a*, right valve; *b*, dorsal aspect; *c*, posterior view.  $\times 45$ .
2. *Cythere pectunculata*, sp. nov.: *a*, left valve; *b*, ventral edge view.  $\times 45$ .
3. *Cythere phylloides*, sp. nov.: *a*, left valve; *b*, dorsal aspect; *c*, posterior view.  $\times 45$ .
4. *Xestoleberis acuminalis*, sp. nov.: *a*, right valve; *b*, ventral aspect; *c*, posterior aspect.  $\times 90$ .
5. *Loxococoncha tumida*, sp. nov.: *a*, right valve; *b*, ventral aspect; *c*, posterior view.  $\times 45$ .
6. *Bythocythere armata*, sp. nov.: *a*, left valve; *b*, dorsal aspect.  $\times 45$ .

On the Structure and Affinities of the Tanganyika Gastropods *Chytra* and *Limnotrochus*. By LETTICE DIGBY. (From the Biological Laboratory, Royal College of Science.) (Communicated by Prof. G. B. HOWES, F.R.S., Sec. Linn. Soc.)

[Read 20th February, 1902.]

(PLATES 38-40.)

THIS paper is based on material which formed part of the collection brought by Mr. J. E. S. Moore from Lake Tanganyika. He has kindly placed at my disposal specimens of both *Chytra Kirkii* and *Limnotrochus Thomsoni*, and has greatly helped me in my work.

#### CHYTRA.

The genus *Chytra* was separated by Moore from Smith's original *Limnotrochus* (4. p. 307), the older generic name being reserved for the reception of the single species *Limnotrochus Thomsoni*. The genus is now represented by a single species, *Chytra Kirkii* (= *L. Kirkii*, Sm.), and is one of the most characteristic forms among the group of peculiar operculate molluscs found only in Lake Tanganyika. It has been generally placed among the Hydrobiidæ (*cf.* Fischer 2.), a family often used as a receptacle for curious and abnormal types which have not been satisfactorily classed. But in 1897, Moore (4. p. 307) regarded it as more probably belonging to the Xenophoridæ, on account of its conchological similarity to numerous fossils which are referred to that group. Up to the present time, however, the anatomy of the animal has never been described.

*External Features.*—The shell (Pl. 38. figs. 1 & 2) has already been described by Smith (8. p. 286). The horny operculum (fig. 3) is of the Littorinoid type, the inner surface being convex and the outer concave. The tentacles are long and filiform, and the eyes are situated on tubercles at their bases.

*Nervous System.*—The nervous system seems to be transitional between the dialyneurous and the zygoneurous types (Pl. 39. fig. 14). The cerebral ganglia (*g.c.*) are closely approximated, and the pleural ganglia (*g.p.*) are separated from them by a

slight constriction. The supra-intestinal cord (*n.sp.*) is considerably elongated; from the supra-intestinal ganglion (*g.sp.*) arise two nerves, the left pallial nerve (*n.p.*') and the visceral (*n.v.*'). A very fine nerve (*c.p.*') connects the left pleural ganglion with the pallial nerve, which it joins soon after its origin from the supra-intestinal ganglion. The sub-intestinal cord (*n.si.*) is somewhat shortened. In like manner the sub-intestinal ganglion (*g.si.*) gives rise to the right pallial (*n.p.*"') and the right visceral nerve (*n.v.*"'). A nerve connects the right pleural ganglion and the right pallial nerve (*c.p.*"'). The visceral nerves (*n.v.*', *n.v.*"') unite by a straight commissure at the base of the mantle-cavity. The pleuro-pedal and cerebro-pedal connectives are long (fig. 15). The pedal ganglia (*g.pe.*) each give off three nerves, two of which run anteriorly and one posteriorly. The otocysts lie close behind the pedal ganglia; they are filled with many barrel-shaped otoliths (fig. 16) of various sizes.

*Radula.*—The radula (Pl. 39. fig. 20) has a feature which is also a characteristic distinctive of the radula of *Hipponyx conicus* (cf. 9. vol. i. p. 162), there being a strong pointed projection on the admedian tooth which overhangs the inner end of its serrated edge. The lateral teeth are sharply pointed and serrated. Possibly this acute form of dentition indicates a carnivorous habit.

*Viscera.*—The mouth is carried on a short snout, and opens into the buccal mass (Pl. 39. fig. 13) (*b.m.*), which leads into a long and very slightly coiled œsophagus (*œ.*). The stomach (*st.*) is two-chambered (Pl. 39. fig. 13 & Pl. 40. fig. 25). The anterior stomachic chamber contains a crystalline style (*s.c.*); the posterior bears a small, but complete spiral cæcum (*cæ.*). The intestine (*i.*) arises from the lower portion of the anterior chamber of the stomach, and coiling twice, bends sharply forward. The rectum (*r.*) attains a considerable dimension, since its walls are very glandular, but it narrows suddenly before opening by the anus (*a.*), which has a circular, thickened rim.

The "liver" (*l.*) occupies a great portion of the visceral mass, and a bile-duct opens at *b*.

The kidney (*k.*) is large, and the renal aperture (*a.r.*) is far back in the mantle-cavity (Pl. 39. figs. 12 & 13).

The heart (*v.* & *aur.*) (Pl. 39. fig. 13) is of the ordinary Monotocardian type. The gill (Pl. 39. fig. 13, *g.*) extends throughout the mantle-cavity, and consists (Pl. 38. fig. 10)

of a single row of plumes (*g.*'), with blunt rounded ends (Pl. 39. fig. 17), each of which is attached along its dorsal edge, and contains a skeletal support continued from the point of attachment. Hypobranchial glands are present (*g.h.*, Pl. 39. fig. 12).

The reproductive aperture (*a.g.*) (Pl. 39. fig. 12) is a wide-oval slit. This, in the female (Pl. 38. fig. 11), leads into a large dilated uterus (*u.*), which is continued to the posterior end of the mantle-cavity, where it is seen to arise from an oviduct (*ov.*), which ramifies in the genital tissue (*g.g.*). This tissue (Pl. 39. fig. 13) is intimately bound up with the "liver" (*l.*), and with it composes the greater part of the visceral hump.

There is an accessory gland-like organ (*g.g.*', Pl. 38. fig. 11) closely adhering to the uterus (*u.*), which protrudes into the mantle-cavity. Its function is unknown, but it may possibly secrete an investment for the eggs. The reproductive organs of the male have not been identified, and it is not known whether the accessory gland-like organ is present in the male, or whether *Chytra Kirkii* is viviparous or not.

*Affinities.*—In attempting to define the affinities of *Chytra*, by far the most important feature presented by this genus is the obvious combination of characters distinctive of several well-known Prosobranchiate forms. Thus the nervous system is strikingly like that of *Capulus* (1. pl. 8. fig. 35). So also, when viewed from the side, the position and relationships of the pedal, pleural, and cerebral ganglia, with their connectives, are very similar to those figured by Bouvier for *Xenophorus*. *Chytra* may be further compared to the Xenophoridae in the obviously similar character of its shell (4. pp. 307 & 317, pl. 23. fig. 6A), and consequently the shape of the body; in the situation of the eyes on the tentacles; in the general character of the gill and gill-plumes; in the filiform osphradium; in the position of the renal aperture; and in the presence of an accessory gland-like organ in relation to the genital apparatus.

This apparent affinity of *Chytra* to the Xenophoridae is perhaps strengthened by a detailed comparison of *Chytra Kirkii* with *Aporrhais pes-pelecani* (*cf.* Pl. 39. fig. 13 & Pl. 40. fig. 22). In both, there is the same arrangement of the buccal mass, a more or less comparable radula (Pl. 39. fig. 20), a very similar gill, and hypobranchial glands (*g.h.*, Pl. 40. fig. 22). Further, the characters of the nervous system of *Aporrhais pes-pelecani*

(Pl. 40. fig. 23) are generally similar to those of *Chytra Kirkii* \*, except that in *Aporrhais* the supra- and sub-intestinal cords are considerably elongated, and there is a direct zygoneurous connection on the right side. In *Chytra Kirkii* there is, however, also a practically zygoneurous condition, the connecting nerve, instead of joining the sub-intestinal ganglion (Pl. 39. fig. 14), joins the pallial nerve immediately after its origin. Lastly, the whole stomachic apparatus is similar: there is a well-developed crystalline style in *Aporrhais* (st., Pl. 40. fig. 22), and the internal valvular portion of the spiral cæcum is present, but not the complete structure. Further, the barrel-shaped otoliths which are found in *Chytra* are also found in *Typhobia* (6. p. 188) and in the Cerithiidae. The presence of the slightly developed spiral cæcum in *Chytra* brings this interesting form into relationship with *Trochus* (7. & Pl. 40. fig. 27), *Pleurotomaria* (fig. 28), and *Nassopsis* (5. p. 189, & Pl. 40. fig. 26). The presence of a crystalline style characteristic of *Chytra* is characteristic of widely different molluscan forms. It is present in all the halolimnic Gastropods of Tanganyika, in some Trochidae, *Pteroceras*, and the Strombidae. These facts suggest that in *Chytra* we are probably dealing with the direct ancestor of the families Hipponycidae and Capulidae, since the genus combines the nervous system of the one and the radula of the other; *i. e.*, two of the most salient features of Prosobranchiate anatomy.

LIMNOTROCHUS THOMSONI. (Pl. 38. figs. 1-9; Pl. 40. fig. 24.)

*Limnotrochus Thomsoni* is now the single species of the genus (1). Like *Chytra*, it is an inhabitant of Lake Tanganyika, living at considerable depths and apparently in solitude, for never more than a single specimen is dredged at a time. Consequently it is difficult to procure the living animal, but the empty shells are pretty common. The conchological characters (Pl. 38. figs. 1, 2) presented by the genus, however, need no comment here, as they have already been fully described and figured (8. p. 285). The operculum (Pl. 38. fig. 3) is "horny" and somewhat oblong in shape, concave towards the inner side, and Littorinoid in character.

\* Haller's figure (3. taf. xviii. fig. 6) of the nervous system of *Chenopus* (*Aporrhais*) *pes-pelecani* and his description of the same (p. 579) is absolutely incorrect. He must either have figured an entirely different animal, or the specimen that he dissected was quite abnormal.



*External Features.*—The general features of the mantle-cavity (Pl. 38. fig. 9), the character of the tentacles, the position of the eyes and of the apertures, are all very like those already described in *Chytra*, the most apparent differences being the smaller size of *Limnotrochus Thomsoni*, the flatter shape of the visceral hump, and the pigmented band down the centre of the snout and on the inner sides of the tentacles.

*Nervous System.*—The nervous system is zygoneurous on the right (Pl. 38. figs. 5, 6). The ganglia and nerves are protected by a closely adhering connective tissue which contains skeletal elements. The cerebral ganglia (*g.c.*) are separated by a distinct cerebral commissure, and are situated decidedly further back than in *Chytra*. The right pleural ganglion (*g.p.*') gives off a fairly long supra-intestinal cord, which connects the right pleural ganglion with the supra-intestinal ganglion. A fine nerve comes off from this cord just before it unites with the supra-intestinal ganglion. This nerve appears to join with another arising from the left pleural ganglion, but I was not able, actually, to see the connection. The supra-intestinal ganglion (*g.sp.*) gives off the left visceral nerve. The sub-intestinal cord springs from the left pleural ganglion, and soon passes into the sub-intestinal ganglion (*g.si.*) which, in the usual way, gives off the right pallial and right visceral nerves. A very short nerve (*z*) connects the sub-intestinal ganglion directly with the right pleural. Viewed from the side (fig. 6), the relative position of the cerebral and pleural ganglia is rather curious, the pleural ganglia being posterior and ventral to the cerebrals and nearly fused with the pedal ganglia, from which they are separated by a very short pleuro-pedal commissure (*c.p.pe.*'), the cerebro-pedal commissure (*c.c.pe.*') being longer. Each pedal ganglion gives off two nerves to the foot, but I was not able to see the nerve leading to the otocysts. The otocysts contain many rectangular otoliths (Pl. 38. fig. 7).

*Radula.*—The radula (Pl. 38. fig. 4) is distinctive, its most striking feature being the blunt protuberance on the underside of each of the two lateral teeth. The admedian tooth is large, and has a broad upper portion, bluntly serrated along its anterior face, which overhangs a lower portion, whose sharply serrated edge is turned towards the median tooth.

*Viscera.*—The mouth leads into a short buccal mass. A pair of salivary glands, diminutive sacculated organs, open into the

buccal cavity. The œsophagus is straight, except for a sharp bend before it opens into the stomach (Pl. 40. fig. 24), which, like that of *Chytra*, has two chambers, the anterior of which contains a large crystalline style. The walls of the posterior chamber are very thin; those of the anterior chamber very thick and muscular. The most remarkable feature about the gastric apparatus of *Limnotrochus* lies, however, in the fact that it possesses an even better developed spiral cæcum (cæ., Pl. 40. fig. 24) than *Chytra* (fig. 25) itself. The base of the cæcum is connected with a longitudinal fold which extends to the anterior chamber; the aperture of a bile-duct (b.) lies below the spiral cæcum. The coils of the intestine, the rectum, and the anus are very similar to those of *Chytra*. The kidney is fairly large, and occupies the same position as in *Chytra*, surrounding the "monotocardian" heart.

The gill (g., Pl. 38. fig. 9) is short, the gill-plumes are triangular, and the osphradium (o.) is filiform.

In both specimens which I dissected, the long slit-like aperture of the genital gland (Pl. 38. fig. 9, a.g.) opened into a considerably dilated sac, slightly curved towards the left side of the animal. In the case of one specimen this was undoubtedly the uterus, as it contained bundles of very long spermatozoa; and in the genital tissue of the visceral coil there were well-developed ova. There is a large accessory gland-like organ (fig. 9, g.g.) like that of *Chytra*, which spreads posteriorly into a tongue-shaped body, partly underlying the uterus (cf. fig. 8).

*Affinities.*—It will have been gathered from the preceding description that *Limnotrochus Thomsoni*, in the general plan of its organization, and in the disposition of the viscera, is distinctly like the genus *Chytra*, but in minor details very different. The shell of *Limnotrochus Thomsoni* (Pl. 38. figs. 1, 2) may be compared to some of the so-called Littorinas of the marine Jurassic deposits, and in particular to *Littorina sulcata* (4. p. 317). It is also dissimilar to that of *Cancellaria*.

Curiously enough, the nervous system of *Limnotrochus* (Pl. 38. fig. 5) is also like that of *Voluta* (3) and *Cancellaria*, there being the same condensation of the cerebral, pleural, and pedal ganglia, and the same zygoneurous condition of the right side. The radula (Pl. 38. fig. 4) cannot be associated with any known type, its nearest approach is to be found in the varieties of the Melanoid group (9. vol. i. p. 121).



Lastly, the pigmented snout, the triangular gill-plumes, so characteristic of the Rhachiglossa, the longitudinal fold and the other features of the stomach, and the simple pouch-like salivary glands, all bring *Limnotrochus* into close relationship with *Typhobia*.

Like *Chytra*, *Limnotrochus* has thus obviously scattered affinities, and it is more difficult to place than even *Chytra* itself. It is undoubtedly allied both to *Chytra* and to *Typhobia*, as well as to the Stromboid group represented by the genera *Strombus* and *Aporrhais*; and it is perhaps more nearly allied to these genera than to any other living types. But, on the other hand, it is quite distinct from them all, and must, at any rate for the present, be regarded as unique.

*List of Papers cited in the Text.*

1. BOUVIER, E. L.—“Système Nerveux, Morphologie Générale et Classification des Gastéropodes Prosobranches.” *Annales des Sciences Naturelles, Zool.* 7<sup>e</sup> série, pp. 1-510 (1887).
2. FISCHER, P.—*Manuel de Conchyliologie et de Paléontologie Conchyliologique.* Paris, 1877.
3. HALLER, B.—“Die Morphologie der Prosobranchier.” *Morphol. Jahrb.* vol. xix. pp. 553-589.
4. MOORE, J. E. S.—“On the Hypothesis that Lake Tanganyika represents an old Jurassic Sea.” *Qu. Journ. Micr. Sci.* vol. xli. pp. 303-321.
5. MOORE, J. E. S.—“Molluscs of the Great African Lakes. Part IV. *Nassopsis* and *Bythoceras*.” *Qu. Journ. Micr. Sci.* vol. xlii. pp. 187-200.
6. MOORE, J. E. S.—“Molluscs of the Great African Lakes. Part I. *Typhobia* and *Bathanalia*.” *Qu. Journ. Micr. Sci.* vol. xli. pp. 181-192.
7. ROBERT, A.—“Gastéropodes : Le Troque.” ‘*Zoologie Descriptive*,’ Paris, vol. ii. pp. 381-415.
8. SMITH, E. A.—“On a Collection of Shells from Lakes Tanganyika and Nyassa, and other Localities in East Africa.” *Proc. Zool. Soc.* 1881, pp. 276-300.
9. TROSCHEL, F. H.—“Das Gebiss der Schnecken.” Band i. Berlin, 1856-1863.

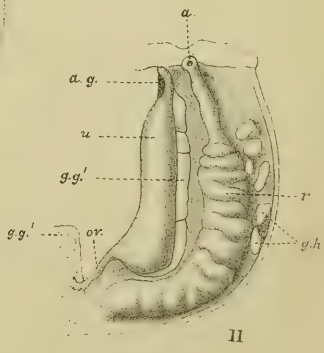
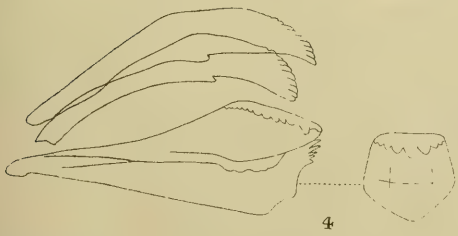
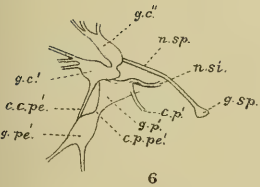
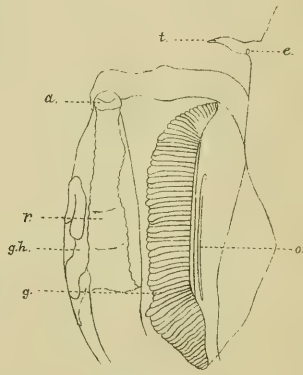
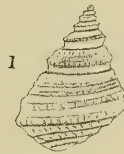
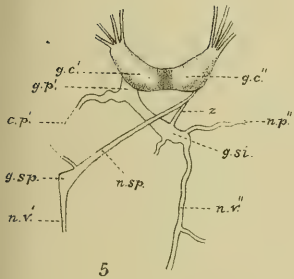
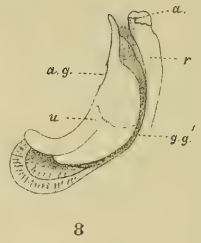
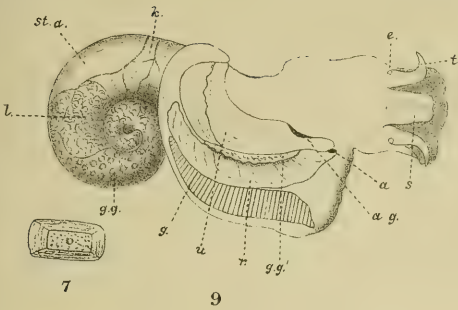
## EXPLANATION OF THE PLATES.

*Reference Letters.*

<i>a.</i> , anus.	<i>g.s.</i> , salivary glands.
<i>b.</i> , aperture of the bile-duct.	<i>g.si.</i> , sub-intestinal ganglion.
<i>a.æ.</i> , opening of the œsophagus into the stomach.	<i>g.sp.</i> , supra-intestinal ganglion.
<i>a.g.</i> , genital aperture.	<i>g.g.</i> , genital groove.
<i>a.i.</i> , opening of intestine leading from the stomach.	<i>i.</i> , intestine.
<i>a.r.</i> , renal aperture.	<i>k.</i> , kidney.
<i>au.</i> , auricle.	<i>l.</i> , liver.
<i>b.m.</i> , buccal mass.	<i>ma.</i> , mantle.
<i>cæ.</i> , spiral cæcum.	<i>m.e.</i> , cut edge of mantle.
<i>c.c.pe.</i> ', left cerebro-pedal connective.	<i>n.p.</i> ', left pallial nerve.
<i>c.p.</i> , pericardial cavity.	<i>n.p.</i> "', right pallial nerve.
<i>c.p.</i> '', left pleural connective.	<i>n.si.</i> , sub-intestinal nerve.
<i>c.p.</i> "', right pleural connective.	<i>n.sp.</i> , supra-intestinal nerve.
<i>c.p.pe.</i> ', pleuro-pedal connective.	<i>n.v.</i> '', left visceral nerve.
<i>e.</i> , eye.	<i>n.v.</i> "', right visceral nerve.
<i>g.</i> , gill.	<i>o.</i> , osphradium.
<i>g.</i> '', gill-plume.	<i>æ.</i> , œsophagus.
<i>g.c.</i> '', left cerebral ganglion.	<i>ot.</i> , otocyst.
<i>g.c.</i> "', right cerebral ganglion.	<i>ov.</i> , oviduct.
<i>g.e.</i> , cut edge of gill.	<i>r.</i> , rectum.
<i>g.g.</i> , genital gland.	<i>s.</i> , snout.
<i>g.g.</i> '', accessory genital gland.	<i>s.c.</i> , crystalline style.
<i>g.h.</i> , hypobranchial gland.	<i>s.s.</i> , style-sac.
<i>g.p.</i> '', left pleural ganglion.	<i>st.</i> , stomach.
<i>g.p.</i> "', right pleural ganglion.	<i>t.</i> , tentacle.
<i>g.pe.</i> , pedal ganglion.	<i>u.</i> , uterus.
	<i>v.</i> , ventricle.
	<i>z.</i> , zygoneurous connection.

## PLATE 38.

- Fig. 1. *Limnotrochus Thomsoni*. Front view of shell.
2. " " Back view of shell. Both natural size.
3. " " Operculum, external face.  $\times 6$ .
4. " " Radula, 2 laterals, admedian and median teeth; from a drawing by Mr. J. E. S. Moore. Magnified.
5. " " Nervous system, dorsal aspect.
6. " " " lateral aspect. Both  $\times 10$ .
7. " " Otolith. Highly magnified.
8. " " Female reproductive organs.  $\times 7$ .
9. " " Mantle-cavity, with mantle reflected to the right.  $\times 7$ .
10. *Chytra Kirkii*. The gill, with mantle reflected to the left.  $\times 12$ .
11. " " Female reproductive organs.  $\times 6$ .



L.D. del.  
M.P. Parker lith.

Parker & West imp.

LIMNOTROCHUS & CHYTRA.

